A facies model for a submarine volcaniclastic apron: the Miocene Manukau volcanic complex, Northland, New Zealand

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SUMMARY

The Manukau Subgroup, New Zealand comprises a Miocene submarine volcaniclastic apron consisting of the products eroded and erupted from a large offshore partially emergent basaltic to andesitic volcanic complex. The submarine volcaniclastic apron is well exposed for over 30 km along the coast. The apron records the depositional history of a marine basin at bathyal water depths and the onset of fan progradation due to volcanism. The exceptional exposure, variation in fan architecture (distal, lobe, upper slope and channel), facies (e.g. sandstone, pumice breccias, conglomerates and pillow lavas) and origin (primary, reworked or epiclastic), allows analysis of a facies model for submarine volcaniclastic fans. The facies analysis shows that submarine volcaniclastic fans differ from other clastic sedimentary fan models in the origin, supply and types of clasts.

Key words: submarine fan, volcaniclastic apron, basaltic-andesite volcanic complex, facies analysis, pumice, pillow lava, conglomerate.

INTRODUCTION

Submarine volcaniclastic aprons and arc-related basins are characterized by steep slopes (~5-360), extremely rapid sedimentation rates (up to ~1 km/my) including single eruptions of several cubic kilometres, fed by more than one point source, and, are prone to seismic activity and uplift events (e.g., Sigurdsson et al., 1980). We describe the facies architecture of submarine volcaniclastic aprons away from the upper volcano flanks and demonstrate the relationship between the basin, lower, middle and upper slope deposits and feeder channels.

The Manukau Subgroup is part of the early Miocene Waitakere Group, erupted and deposited from the Northland Volcanic Arc, New Zealand, which comprised two subparallel SE trending belts of island volcanoes on the western and eastern margins of a 1000-2000 m-deep intra-arc basin (Hayward, 1993; Isaac et al., 1994). Aeromagnetic, gravity and seismic surveys have revealed several offshore igneous bodies (Davey, 1974). The southern centre (Manukau volcanic complex) from the western volcanic belt (Waitakere Group) today lies west of the current terrestrial outcrops of the Waitakere Group. The Manukau volcanic complex is the southwestern-most centre and was dominantly basaltic-andesitic in composition. The eastern sector of the submarine volcaniclastic apron is well exposed for over 30 km along the coast of western Auckland. Dramatic changes in lithofacies character occur downslope and with time due to changes in eruption style, eruptive hiatuses, uplift and eastward vent migration.

This abstract presents a summary of a manuscript currently in review in the Bulletin of the Geological Society of America.

METHOD

Lithofacies analysis at various field sites involved graphic logs geological cross sections. Further component and textural data was collected from photographs and thin sections.

RESULTS

Upper submarine slope facies

The upper submarine slopes of the Manukau volcanic complex are dominated by the Piha Formation. This formation is very thick (>800 m) and extensive (>20 km across) and comprises stratified course conglomerates with minor sandstone. Most clasts are reworked subangular to subrounded fragments of lavas. The Piha Formation varies between insitu deposits and extensively slumped horizons. It also hosts cross cutting dikes, interbedded lavas and hyaloclastite, and minor interbedded pumiceous units indicating contemporaneous volcanism. The origin for the clasts was presumably in streams, at the shoreline, and down to wave base (0-50 m). Downslope, the conglomerates interfinger with finer grained pumiceous pebbly sandstones (Nihotupu Formation). The depositional environment of the Piha Formation has been constrained as shelf to lower bathyal; 0-2000 m (Hayward and Buzas, 1979), with the majority of sediments probably accumulating at 200-1000 m water depth.

Lower fan facies

The volcaniclastic facies of the lower fan is dominated by the Nihotupu Formation. The lower-most parts comprise more than 60 m of regularly thinly bedded mudstone and sandstone.
with minor, very thin, pumice and crystal-rich coarse tuffs. Mud and sand clasts were dominated by rounded to angular reworked grains of mafic compositions, although scattered pumice and wood fragments are also present. The upper part includes laterally discontinuous resedimented pumiceous pebbly sandstone, tabular, poorly sorted conglomerates and a thick sequence of pillow lavas. Benthic foraminiferal faunas indicate that the Nihotupu Formation was deposited in relatively deep (1000-2000 m), mid bathyal depths (Hayward, 1976, Hayward and Buzas, 1979).

**Channel-fill facies**
The outline of two channels are exposed that cut into the lower fan facies: a northern channel 650 m wide and ~70 m deep, and a partly fault-controlled southern more extensive channel 2.1 km wide and 35-125 m deep. The channels are infilled with the younger, coarser and more proximal Tirikohua Formation. The lower part of the channel-fill comprises conglomerate overlain by a middle part of thickly bedded sandstone. This initial channel fill largely records reworking of basaltic-andesite and only very minor pumice and scoria is present. This lower part has a gradational and somewhat transitional contact with the overlying and channel overflowing pumiceous and scoriaceous upper part. This upper channel-fill sequence is dominated resedimented pyroclasts in thick, scour-fill beds. The channel over-fill facies comprises discontinuous, thin to thickly bedded pumice lapilli tuff and thinly bedded, low-angle cross stratified mixed resedimented and reworked facies.

Influxes of wellrounded cobbles and pebbles came from the shallow shelf, intertidal zone (0-50 m) or fluvial environment. Abundant pyroclasts were sourced from contemporaneous pyroclastic eruptions. Sparse macrofauna consists of displaced mid shelf-upper bathyal sand dwellers and pelagic forms suggesting upper bathyal (200-600 m) deposition for the Tirikohua Formation (Hayward, 1977).

**CONCLUSIONS**
The Manukau Subgroup provides a record of a submarine volcaniclastic apron that was formed on the slopes of a large emergent basaltic-andesite volcanic island complex. The overall model for the volcaniclastic apron is a distally quiet deep-water environment dominated by suspension settling being onlapped by fan progradation induced by resedimentation of pyroclasts. Conglomerates accumulated on the upper more proximal slopes that were prone to slumping. These upper slope conglomerates formed a braided system of low aspect ratio channels and differ from the single-deep feeder channel arrangement of upper sedimentary fans. This relatively stable phase of sedimentation was punctuated by accelerated fan progradation due to substantial uplift causing channel incision. The channels were then infilled and abandoned by a thinning and fining upwards sequence from initially reworked to later resedimented pyroclastic sedimentation. Satellite vents contributed effusive and pyroclastic deposits throughout the apron history. Although pyroclastic eruptions contributed to fan progradation, deep channels the apron were produced only after significant uplift events.

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